Neogene lithological units at the west end of the Guadalquivir Basin and their correlations with the Huelva-1 borehole (Huelva - Spain)

Unidades litológicas del Neógeno en el extremo oeste de la Cuenca del Guadalquivir y su correlación con el sondeo Huelva-1 (Huelva - España)

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Abstract: A detailed surveying and a new geological map of the sheet at 1:50.000 number 999/1016 (Huelva - Los Caños), located at the west end of the Guadalquivir Basin, has been carried out. This data allows us to propose a new organization of the lithological units present at the west side of the Odiel River. These units include all the sedimentary record in this sector of the Guadalquivir Basin, ranging from Tortonian to Pliocene, but with shallower and coarser facies that are only present in this part of the basin. This fact is due to the location of the area, probably less subsiding due to a longer distance from Betic-Rif orogen. The lithological units are described concisely and a correlation with the core of the Huelva-1 borehole and with the outcrops of Huelva – Palos de la Frontera area is also proposed. The units are organized in a stack of sequences with a progradational pattern, typical of a basin margin, and highlighting a gradual reduction of the accommodation space in the late Messinian and during the Pliocene.

Key words: Guadalquivir Basin, Neogene, lithofacies, lithological units, stratigraphic correlation

Resumen: *Se ha realizado un reconocimiento detallado y un nuevo mapa geológico de la hoja a 1: 50.000 número 999/1016 (Huelva - Los Caños), situada en el extremo oeste de la Cuenca del Guadalquivir. Estos datos nos han permitido proponer una nueva organización de las unidades litológicas presentes en el lado oeste del río Odiel. Estas unidades incluyen el registro sedimentario completo de este sector de la Cuenca del Guadalquivir, que va desde Tortoniense al Plioceno, pero mostrando unas facies más someras y gruesas que solo están presentes en esta parte de la cuenca. Este hecho se debe a la ubicación de la zona, probablemente menos subsidente debido a su mayor distancia con respecto al orógeno Bético-Rifeño. Las unidades litológicas se describen de forma concisa y se propone también su correlación con el testigo del sondeo Huelva-1 y los afloramientos de la zona de Huelva - Palos de la Frontera. Las unidades litológicas se organizan formando un apilamiento de secuencias con un patrón progradacional, típico de un borde de cuenca, y ponen de manifiesto una reducción gradual del espacio de acomodación a finales del Messiniense y durante el Plioceno.*

Palabras clave: *correlación estratigráfica, Cuenca del Guadalquivir, Neogeno, litofacies, unidades litológicas*

INTRODUCTION

The Guadalquivir Basin (GB) is a foreland basin developed during the Neogene and Quaternary between the Betic Cordillera and the Iberian Massif (Sierro et al., 1996). The GB follow an ENE-WSW direction, formerly opened to the Mediterranean Sea and the Atlantic Ocean (Tortonian – early Messinian), but currently only towards the Atlantic (Gulf of Cadiz). As a result of the low-relief of the territory, the erodibility of the sediments and intense agricultural tillage and forestry works, the outcrops of Neogene series at the western end of the GB are still poorly researched. Additionally, the lithofacies of the sediments present remarkable differences, and correlations between the Neogene sediments located at the east and west sides of the Odiel River are difficult. A detailed surveying and new geological mapping (Salazar and Martín-Banda, in press) of the sheet at 1:50.000 number 999/1016 (Huelva - Los Caños) have provided a better knowledge of the Neogene deposits, showing a general westward lateral variation to coarser and shallower lithofacies. These new data allows us to propose a new organization of the lithological units in the area (Fig.

1). The lithological units located at the west side of the Odiel River (Cartaya - El Rompido and Aljaraque - El Portil areas) are described firstly, and a correlation with the core of the Huelva-1 borehole (Larrasoaña et al., 2008) and the well-documented outcrops of Huelva – Palos de la Frontera area (Mayoral and Pendón, 1986-87; Civis et al., 1987) is also proposed (Fig. 3).

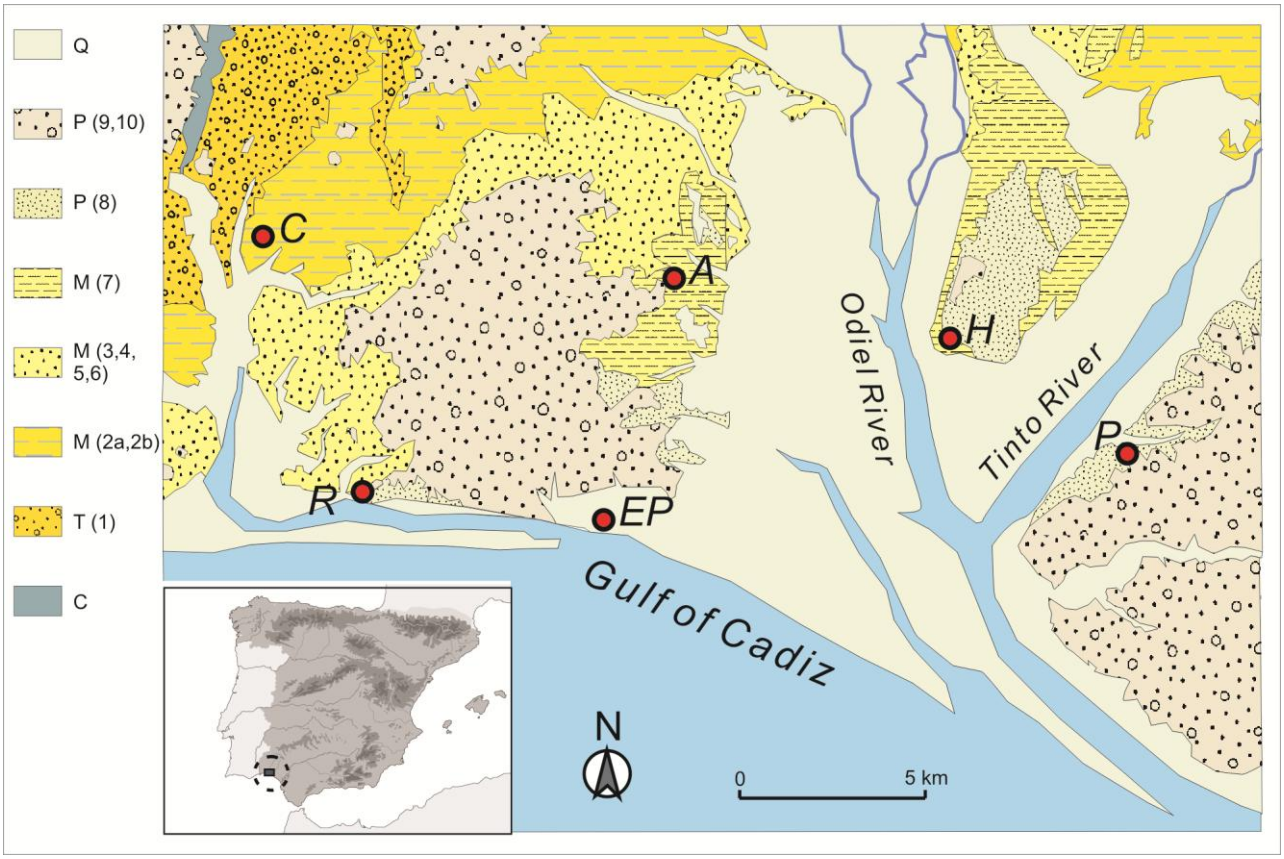

FIGURE 1. *Simplified geological map of sheet nº 999/1016 (Huelva - Los Caños). Locations: C = Cartaya, R = El Rompido, A = Aljaraque, EP = El Portil, H = Huelva, P = Palos de la Frontera. Units: C = Carboniferous, T = Tortonian, M = Messinian, P = Pliocene, Q = Quaternary. The numbers in brackets correspond to the lithologic units of Figure 3 and text.*

NEOGENE LITHOLOGICAL UNITS AT THE WEST OF ODIEL RIVER

The oldest Neogene sediments outcrop at the north of Cartaya, and are composed of 20 to 30 m of sands and gravels, with very few bioclasts (unit 1) and resting directly upon the Carboniferous substrate. Just over, a disconformity underlies 50-60 m of yellowish-grey silts (unit 2a; shoreface-offshore facies) with some bivalves, solitary corals and frequent bioturbation (local section at the highway A-49; Fig. 2). This unit grades westward into very fine sands and to clays and to calcareous silty clays upward and to the east (unit 2b; continental slope facies) and is overlaid by a set of coarsening - upward shoreface sands with abundant carbonate nodules, *Amussium cristatum* and cetaceans remains (unit 3), pointing to the beginning of a progradation (Fig. 2).

The sedimentation continues with 30-40 m of pale reddish-yellow poorly sorted sands (local section at Tojadillos quarry, near Aljaraque), with visible muscovite grains and intense bioturbation (unit 4; foreshore facies). Westward, this unit is overlaid by 10-20 m of reddish-brown sandy gravels with cut and fill structures, rip-up clasts, normal graded bedding, trough cross-stratification and imbricated clasts (unit 5; fluvial facies).

The overlying units 7 and 8 have different distribution and facies in the Aljaraque - El Portil area and Cartaya - El Rompido area. At Aljaraque – El Portil, 50-60 m of scarcely bioturbated grey mudstones with some fragments of bivalves crop-out extensively (unit 7; offshore facies) and is overlaid by unit 8, the early Pliocene Huelva Sand Formation of shoreface subenvironments (Civis et al., 1987). But at Cartaya – El Rompido the unit 7 is absent and the Huelva Sand rest directly over the fluvial unit 5 at El Rompido. Unit 8 contains 25-30 m of pale-yellow fine and very-fine silty sands, with abundant fossils and significant amounts of glauconite at the base (González-Regalado and Ruiz, 1988), with a thin bed of biocalcirudite at its base at El Rompido cliffs.

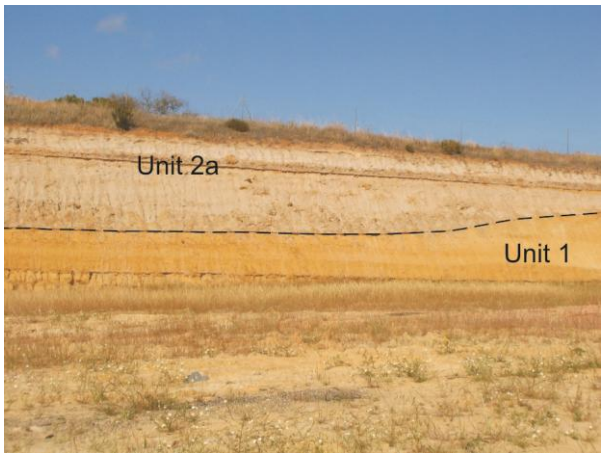

FIGURE 2. *Disconformity between unit 1 (equivalent to Niebla Formation) and unit 2a (equivalent to Gibraleón Formation) at the cut face of the highway A-49.*

The termination of all these formations is a truncation that allows the unit 9 to rest over, and partially cover, their outcrops. Unit 9 is composed by reddish grey to deep red sand, medium to coarse grained, becoming very coarse and gravely to the top (foreshore facies). The thickness is variable (from 3-4 m to more than 10 m in this area) and bioturbation is intense. Overlaying this unit appears a 3-10 m thick fluvial unit, composed of sand and gravel (unit 10), sometimes with ferruginous cement and tableland shape.

CORRELATION WITH HUELVA-1 BOREHOLE AND HUELVA – PALOS AREA

The unit 1 marks the beginning of the Miocene transgression (Fig. 3) and the presence of *Heterostegina* sp. ensures a Tortonian age and its correspondence with Niebla Formation (Civis et al., 1987; Abad, 2010). Unit 2a was studied by Sierro (1985) at Cartaya quarry, considering it within *Turborotalia humerosa* biozone (Tortonian). *Globigerinoides elongatus* and *Neogloboquadrina acostaensis* are present in unit 3, indicating a Messinian age. Therefore, both units must be considered as equivalents of the basal part of Tortonian-Messinian Gibraleón Clay Formation (Civis et al., 1987), but in shallower and coarse facies.

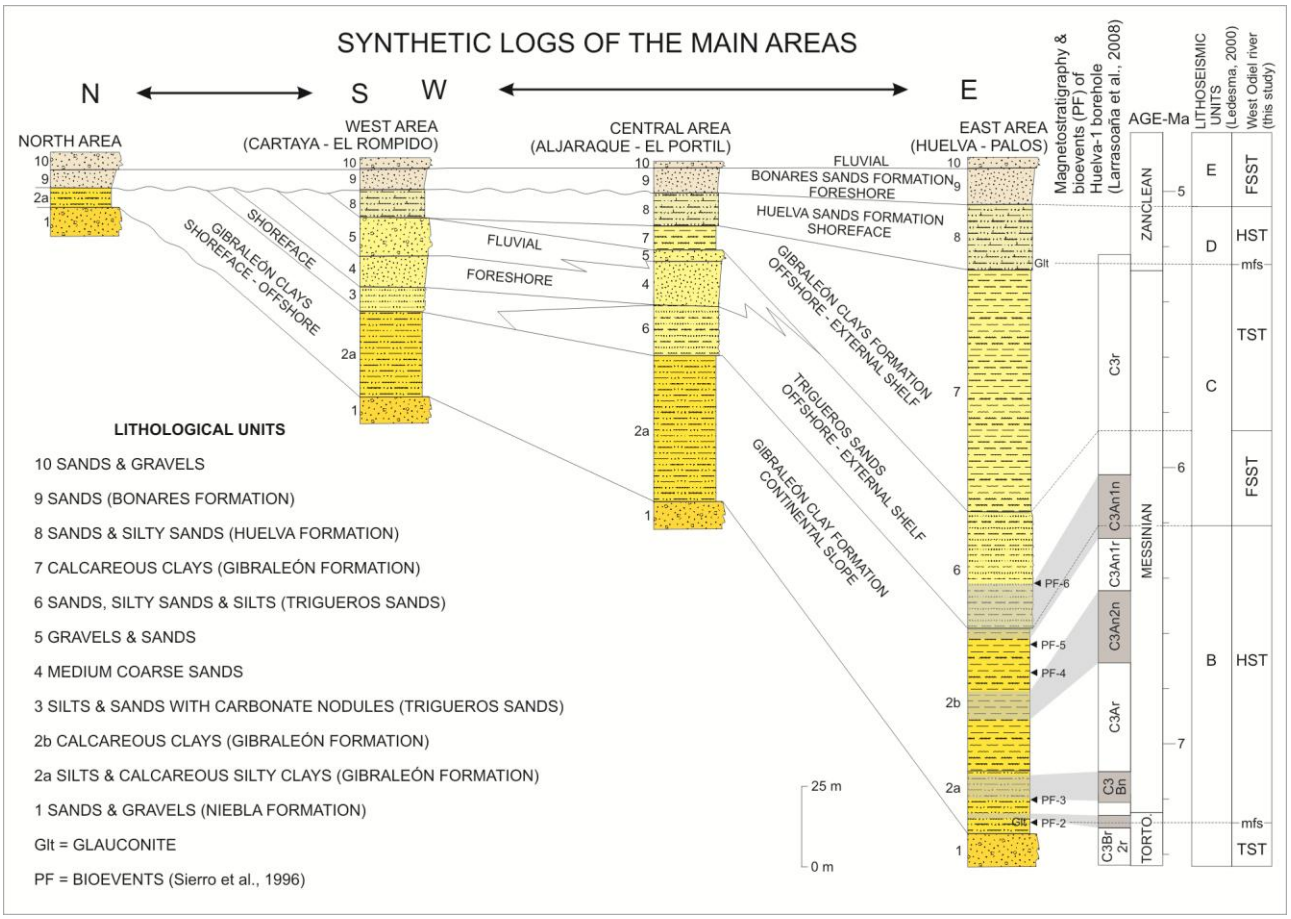

FIGURE 3. *Correlation panel of synthetic logs of the main areas (see location in Figure 1) with Huelva-1 borehole Huelva – Palos de la Frontera area. TST = transgressive systems tract, mfs = maximum flooding surface, HST = highstand systems tract, FSST = falling stage systems tract.*

The presence of *Globorotalia margaritae* in unit 7 allows us to correlate these sediments with the upper part of Gibraleón Clay, above the bioevent PF-6 (FO of *G. margaritae* group) of Sierro et al. (1996). Therefore, units 4 and 5 must also be considered Messinian. Both units conforms the upper part of a progradational sequence, in relation with the turbidites of unit 6 Trigueros Sand (Sierro et al., 1996). The equivalence of units 8 and 9 with Huelva Sand Formation and Bonares Sand Formation (Mayoral and Pendón, 1986-87) has been previously proposed by various authors (González-Regalado and Ruiz, 1988).

DISCUSSION AND CONCLUSIONS

Unit 1 has been interpreted as a transgressive system tract (TST) and units 2a and 2b as the subsequent highstand systems tract (HST); being the maximum flooding surface (mfs) the glauconitic levels near the boundary of both units (Sierro et al., 1996; Ledesma, 2000; Abad, 2010). At the northwest of Cartaya the boundary between Niebla (unit 1) and Gibraleón (unit 2a) formations is erosional (Fig. 2) and the typical glauconite level does not exist. This fact, due to local erosion within a context of widespread transgression, maybe interpreted in relation with a slight tectonic uplift.

Units 3, 4 and 5 show a progradational trend, contemporaneous with Trigueros Sand turbidites, therefore, in relation with the lithosismic unit C of Ledesma (2000), a regressive and progradational sequence linked to a forced regression, and in relation with the sea-level drop at chron C3r at the Montemayor-1 core (Pérez-Asensio et al., 2012). The following unit (unit 7; offshore facies) represents a new TST at the west side of Odiel River, with a transgressive surface at the base. The unit 8 has been considered a HST, with a mfs near the Miocene-Pliocene limit, by Sierro et al. (1996). Units 9 and 10 form the last stratigraphic sequence (Sierro et al., 1996; Ledesma 2000), with a clearly unconformity at the base of Bonares Sand Formation at the west side of Odiel River.

The location of the area, probably less subsiding due to a longer distance from Betic-Rif orogen, allowed the preservation of shallower facies, not present in other parts of the basin. The lithological units are organized in a stack of sequences with a progradational pattern, typical of a basin margin, and highlighting a gradual reduction of the accommodation space in the late Messinian and during the Pliocene.

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